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NATIONAL DEFENSE RESEARCH COMMITTEE

of

OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

WAR METALLURGY DIVISION

Progress Report

on

EXAMINATION OF ENEMY MATERIEL (OD-113)(AC-77)(N-119): METALLURGICAL EXAMINATION OF WING HINGE FITTINGS FROM JAPANESE "FRANCES" AIRCRAFT

by

L. H. GRENELL, A. B. WESTERMAN, AND H. W. GILLETT
BATTELLE MEMORIAL INSTITUTE

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August 31, 1945

August 31, 1945

To: Dr. James B. Conant, Chairman
National Defense Research Committee of the
Office of Scientific Research and Development

From: War Metallurgy Division (Div. 18), NDRC

Subject: Progress Report on "Examination of Enemy Materiel (OD-113)(AC-77)(N-119): Metallurgical Examination of Wing Hinge Fittings from Japanese 'Frances' Aircraft"

The attached progress report submitted by H. W. Gillett, Technical Representative on NDRC Research Project NRC-32, has been approved by representatives of the War Metallurgy Committee in charge of the work.

This report presents the results of an examination of sections of two wing hinge fittings from the Japanese "Frances" #466 aircraft for types of material, coatings, methods of manufacture, and heat treatment.

Acceptance as a satisfactory progress report under Contract OEMsr-722 with Battelle Memorial Institute is recommended.

Respectfully submitted,

Louis Jordan
Technical Aide to the Chief
War Metallurgy Division, NDRC

Enclosure

PREFACE

This report is pertinent to the problems designated by the War Department Liaison Officer with NDRC as OD-113 and AC-77, and by the Navy Department as N-119, and to the project designated by the War Metallurgy Committee as NDRC Research Project NRC-32.

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NDRC RESEARCH PROJECT NRC-32, OEMsr-722

EXAMINATION OF ENEMY MATERIEL

Metallurgical Examination of Wing Hinge Fittings from Japanese "Frances" Aircraft

July 26, 1945

From:

BATTELLE MEMORIAL INSTITUTE

Report Prepared By:

L. H. Grenell
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Research Engineers

H. W. Gillett
Official Investigator

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FOREWORD

Sections of two wing hinge fittings from the Japanese "Frances" #466 aircraft were received at Battelle Memorial Institute from the Technical Air Intelligence Center, Anacostia, D.C., for metallurgical examination. The fittings numbered CEE 27047 and 27048 were assigned BMI Nos. 842 and 843, respectively. The "Frances" #466 is a Navy operational torpedo bomber, dive bomber, and reconnaissance plane, which was manufactured by Nakajima Hikoki K.K. in February 1944.

SUMMARY

The only steel parts of the wing hinge fittings examined were the spar fittings which were forged and machined from SAE X-4130 and 3335 types of steel. The SAE X-4130 was manufactured in a basic open-hearth or electric furnace with Si as the deoxidizer. The SAE 3335 was acid electric furnace type steel and was deoxidized with Al. The use of alloy scrap in the furnace charges was suggested by the high residual Ni in the SAE X-4130 and Mo in the SAE 3335. The steels were of aircraft-quality cleanliness. Both spar fittings were quenched and tempered, and had tensile properties which were normal for the particular materials and hardnesses. These parts were coated with a black phenolic resin varnish over a red iron oxide primer.

The other parts consisted of Al alloys of the Alcoa X76S, 24S, 17S, and A108 types in the form of extrusions, flat and bent sheet, a forging, and a casting. All of these parts, with the exception of the Alcoa A108 type casting which was in the as-cast condition, were solution heat treated and aged; one of the spar sections was overaged. The heat treating practice was fair, except in a few parts in which $CuAl_2$ was

incompletely dissolved. Some of the Alcoa X76S and 24S type sheet were clad with material similar to 0.7% Si-0.5% Mn-1.00% Mg-Al base alloy.* The cladding material thickness on each side was approximately 4% of the total thickness of the sections which ranged from 0.081" to 0.101", with one exception which was 5%. No diffusion was visible between the core and the cladding. Anticorrosion protection was achieved by the use of combinations of cladding, anodic coatings, and paint; most of the parts were protected by all three coatings. There was no evidence of corrosion on any of these parts.

Except for the spar fittings, which were manufactured from different types of steel, the same respective parts of the two wing hinge fittings were fabricated from the same materials.

ECONOMIC CONSIDERATIONS

The materials - in particular, the Alcoa X76S type alloy and the types of steel - and the methods of inhibiting corrosion used in the manufacture of the wing hinge fittings indicates the emphasis which the Japanese place upon excellence of aircraft parts. No signs of conservation of strategic alloying elements were found in the high Cu Alcoa X76S type alloy or in the Ni-Cr and Cr-Mo steels. The presence of anodic coatings alone, or with alloy cladding, or with alloy cladding and paint on the Al alloy parts suggests that the Japanese were willing to go to great lengths to insure against corrosion in the wing hinge fittings; Cr was used in the Alcoa X76S also for this purpose. The iron oxide primer with a top coat of phenolic resin varnish on the steel spar fittings was adequate for minimizing corrosion.

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*Cladding on R-301 alloy.

The thickness of the alloy cladding - 4% with the exception of 5% on one part - was generally less than that (5%) which would be used in the U.S. on these particular sections. The presence of undissolved $CuAl_2$ in some of the parts suggested careless heat treating practice. The use of different steels for the spar fittings of the two wing hinge fittings may be accounted for on the basis of broad specifications, as shown by studies of captured Japanese specifications.

DISCUSSION OF RESULTS

The wing hinge fitting sections as received are shown in Figure 1.

Type of Material

Analyses of the steel spar fittings and of selected Al alloy parts are presented in Table 1. The ferrous parts were macroetched in 50% HCl; the Al alloy parts in Flick's etch. The microstructure and hardness values of all parts were studied. Microstructures of a spar section and of a clad spar web are shown in Figures 2 and 3, respectively. The physical properties of the spar fittings are listed, together with general data on all parts in Table 2.

Paint

The blue-green paint found on several of the Al alloy parts consisted of a modified phenolic resin varnish with Prussian blue dye. The steel spar fittings were coated with red iron oxide primer and top coats of black phenolic resin varnish. Both types of paint were fairly adherent.

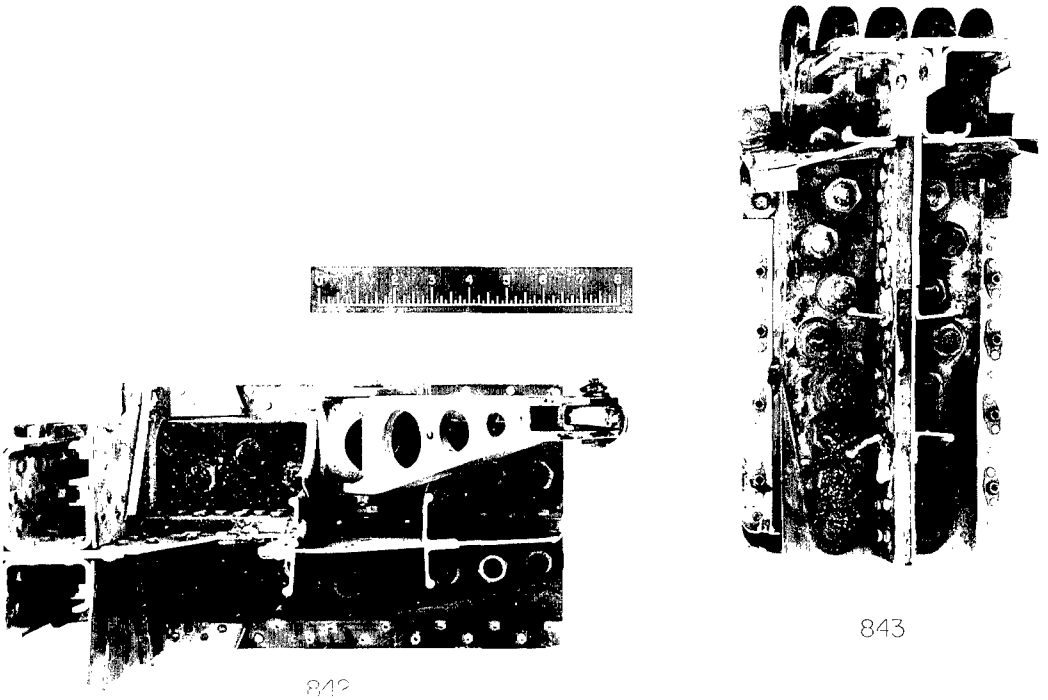

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Figure 1. Sections of Wing Hinge Fittings from Japanese "Frances" #466 Aircraft

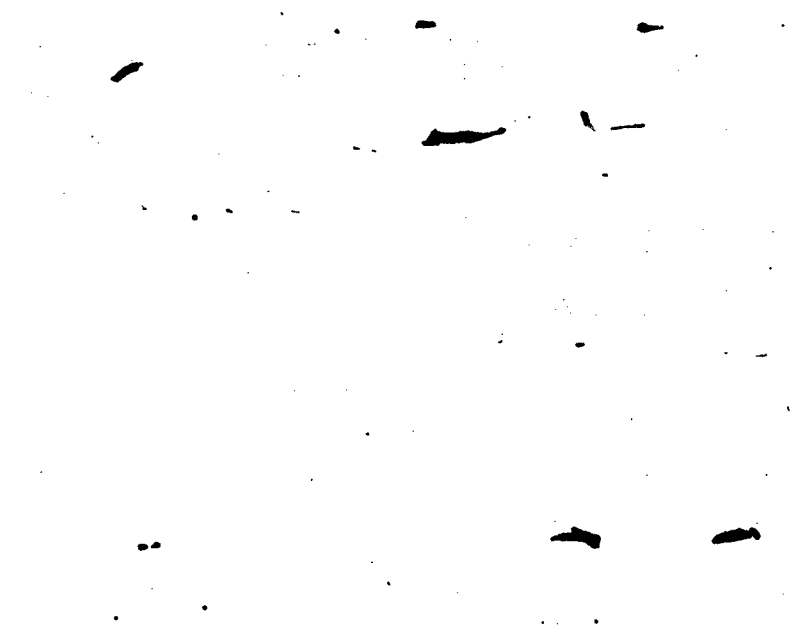

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Figure 2. Microstructure of Spar Section (BMI 842-1) - Alcoa X76S type alloy with high Cu and Zn.

300X 0.5% HF 38080

Figure 3. Microstructure of Clad Spar Web (BMI 842-3) - Alcoa X76S type alloy (with high Cu) clad with 0.7% Si-0.5% Mn-1.0% Mg-Al base type alloy.

TABLE 1. ANALYSES OF PARTS OF WING HINGE FITTINGS FROM JAPANESE "FRANCES" #466 AIRCRAFT

BMI No.		C	P	S	Mn	Si	Ni	Cr	W	V	Mo	Cu	Sn	Al	Ti
Ferrous															
842-2	Spar Fitting	0.29	0.033	0.022	0.51	0.33	0.30	1.19	<0.04	<0.02	0.17	0.33	0.047	0.005	0.004
843-2	Spar Fitting	0.36	0.014	0.010	0.52	0.27	3.09	0.76	<0.04	<0.02	0.07	0.24	0.010	0.041	0.006

Nonferrous		Cu	Si	Mg	Mn	Zn	Cr	Fe
842-1	Spar Section	2.14	0.37	1.40	0.56	8.97	0.14	0.28
843-1	Spar Section	2.10	0.31	1.45	0.57	8.91	0.17	0.24
842-3	Spar Web	3.0	0.22	1.70	0.60	7.5	0.2	0.27
843-3	Spar Web	3.0	0.20	1.64	0.65	7.75	0.2	0.29
842-4	Spar Fitting Backing Section	4.4	0.20	1.5	0.62	-	-	0.27
843-4	Spar Fitting Backing Section	4.7	0.18	1.5	0.60	-	-	0.25
842-8	Spar Wing Hinge	3.9	0.25	0.63	0.61	-	-	0.21

Note: Spectrographic analysis showed all cladding to be similar to that on R-301 alloy - namely, 0.7% Si-0.5% Mn-1.0% Mg-bal. Al.

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TABLE 2. GENERAL DATA ON PARTS OF WING HINGE FITTINGS FROM JAPANESE "FRANCES" #466 AIRCRAFT

BMI No.	Name	VDH	Type of Material	Remarks
842-1	Spar Section	163	Alcoa X76S with high Zn and Cu	Extruded and machined; solution heat treated and aged; anodized; blue-green paint.
842-2	Spar Fitting	224	SAE X4130 steel	Forged and machined; slack quenched and tempered; T.S. 107,000 p.s.i., Y.S. (0.2% offset) 76,000 p.s.i., El. (in 1") 22%, R.A. 64%; clean; red primer coat with black paint; bolted to spar section.
842-3	Spar Web	169	Alcoa X76S with high Cu	Sheet 0.081" thick; solution heat treated and aged; 0.004" thick Al alloy cladding; no diffusion; anodized; blue-green paint; riveted to spar section.
842-4	Spar Fitting Backing Section	144	Alcoa 24S alloy	Sheet 0.094" thick; solution heat treated and aged; 0.004" thick Al alloy cladding; no diffusion; anodized; blue-green paint; riveted to spar fitting.
842-5	Spar "U" Brace	136	Alcoa 24S type alloy	Sheet 0.101" thick bent to shape; solution heat treated and aged; anodized; riveted to spar web.
842-6	Spar "U" Brace	126	Alcoa 24S type alloy	Sheet 0.101" thick bent to shape; solution heat treated and aged; 0.004" thick Al alloy cladding; no diffusion; anodized; blue-green paint; riveted to spar web.
842-7	Spar "L" Brace	145	Alcoa 24S type alloy	Extruded; solution heat treated and aged; anodized; riveted to spar web.
842-8	Spar Wing Hinge	111	Alcoa 17S alloy	Forged and machined; solution heat treated and aged; anodized.
842-9	Spar Accessory	78	Alcoa A108 type alloy	Cast; in as-cast condition; anodized; riveted to three anodized extrusions.
843-1	Spar Section	92	Alcoa X76S with high Zn and Cu	Extruded and machined; solution heat treated and overaged; $CuAl_2$ incompletely dissolved; anodized; blue-green paint.
843-2	Spar Fitting	318	SAE 3335 type steel	Forged and machined; quenched and tempered; T.S. 144,000 p.s.i., Y.S. (0.2% offset) 130,000 p.s.i.; El. (in 1") 26%, R.A. 66%; clean; red primer coat with black paint; bolted to spar section.

Table 2. General Data-"Frances" Wing Hinge Fittings

BMI No.	Name	VDH	Type of Material	Remarks
843-3	Spar Web	142	Alcoa X76S with high Cu	Sheet 0.081" thick; solution heat treated and aged; $CuAl_2$ incompletely dissolved; 0.003" thick Al alloy cladding; no diffusion; anodized; blue-green paint; riveted to spar section.
843-4	Spar Fitting Backing Section	136	Alcoa 24S alloy	Sheet 0.092" thick; solution heat treated and aged; 0.004" thick Al alloy cladding; no diffusion; anodized; blue-green paint; riveted to spar fitting.
835-5	Spar "U" Brace	97	Alcoa 24S type alloy	Sheet 0.101" thick bent to shape; solution heat treated and aged; $CuAl_2$ incompletely dissolved; 0.004" thick Al alloy cladding; no diffusion; anodized.

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ABSTRACT

Results of examination of sections of two wing hinge fittings from the Japanese "Frances" 466 aircraft are presented. Steel parts examined were spar fittings which were forged and machined from SAE X-4130 and 3335 types of steel. Both spar fittings were quenched and tempered, and had tensile properties which were normal for the particular materials and hardnesses. The other parts considered consisted of Al alloys of various Alcoa types in form of extrusions, flat and bent sheet, a forging, and a casting. All castings with the exception of one were solution heat treated and aged.

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